

METHOD FOR ANALYZING FINAL TEST PARAMETERS

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I hereby certify that the attached English document is an accurate translation of
Taiwan application No. 091138168 into English. I am fluent in both Chinese and English,
5 and certify that the attached English document is an accurate translation of the
corresponding Taiwan patent application.

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METHOD FOR ANALYZING FINAL TEST PARAMETERS**1. Field of the Invention**

5 The present invention relates to a method for analyzing process parameters, and more particularly, to a method for analyzing final test parameters.

2. Description of the Prior Art

10 In the arena of semiconductor manufacturing, many processes, such as photolithography processes, etching processes, ion implantation processes, etc., are required to complete the fabrication of a semiconductor product. A large amount of equipment and complicated 15 procedures are required in a semiconductor manufacturing process. Therefore, engineers in the field spend a great deal of time ensuring the proper operation of equipment, sustaining or improving production yield rates, detecting and verifying 20 problems, and periodically maintaining facilities for production and the like so as to ensure that overall operations are in good order, and to ensure the production of satisfactory products.

25 In general, in order to identify semiconductor processing problems, data such as process parameter data, in-line quality control (in-line QC) data, defect inspection data, sample test data, wafer test data, and final test data, are analyzed. The final test data 30 contains testing values acquired by performing testing of semiconductor devices after dicing and packaging procedures.

In prior art, please refer to Fig. 1, step 101 is

first executed by an engineer to perform various final test items upon each semiconductor device after the packaging process. For example, the testing of certain electrical characteristics is performed on the pins 5 of the semiconductor devices.

Next, in step 102, the results acquired from various final test items performed upon each semiconductor device is analyzed by an engineer to detect products 10 having abnormal final test results.

In step 103, the possibly faulty process step or the possibly faulty testing step is determined by way of personal experience acquired by an engineer, and 15 is based upon the final test results of the abnormal products selected from step 102. A possibly faulty process step may be, for example, a packaging process, and the possibly faulty testing step, for example, may be an in-line quality control step, a sample test, etc.

20 Finally, in step 104, the engineer identifies the malfunctioning equipment by checking the equipment utilized in the process step determined in step 103, or reset various preset values of the testing step 25 determined in step 103. For example, the engineer may first determine that one of the pins in the semiconductor device is out of order, search for the process step in which the packaging process is performed, and find out which equipment is malfunctioning, such as the wire 30 bonding equipment, the molding equipment, etc. In addition, if the engineer determines that the problem of the semiconductor device is correlated to a previous manufacturing processes, then it can be assumed that an in-line testing step, executed previously, has also

probably gone wrong, to cause the problematic products are not able to be checked out. Under such circumstances, the engineer will have to revise various predefined specs of the in-line testing step to ensure 5 that the problem is not repeated.

However, since the analysis results (step 103) and the revised numerical values (step 104) are determined according to an engineer's personal experience, the 10 accuracy and confidence level of the final analysis results are open to question. Furthermore, human resources in semiconductor manufacturing plants change frequently. It is not easy to transfer an engineer's personal experience. The capacity of each engineer 15 is a limited resource, meaning that the engineer is unable to look after the operational status of all the equipment in the plant. When the testing results from semiconductor products indicate abnormalities, it is often difficult for engineers, lacking in experience, 20 to rapidly and correctly determine which process point is responsible for the problem. As a result, a lot of time is wasted to undertake related research, and even worse, incorrect decisions are made. This will not only reduce process efficiency, but also increases 25 costs. Furthermore, the in-line production status cannot be improved in time to increase the yield rate.

It is therefore very important to provide an analytical method to rapidly and correctly determine 30 which point in a semiconductor manufacturing process has caused a problem to occur, and to correct the predefined specs when the final test data of the semiconductor products indicates abnormalities.

3. Summary of Invention

In view of the above, it is an objective of the claimed invention to provide a method for analyzing final test parameters to rapidly and correctly determine which point causes problems to occur when final test data of semiconductor products indicates abnormalities.

It is another objective of the claimed invention to provide a method for analyzing final test parameters to revise the control spec of in-line quality control or the sample test according to the testing results acquired from the final test and the in-line quality control or the sample test.

15

It is a feature of the claimed invention to analyze various testing data and equipment data of inferior product lots by utilizing a statistical analysis means and a commonality analysis means, using superior product lots as a reference group.

Accordingly, for achieving the above mentioned object, the claimed invention method for analyzing final test parameters is utilized for analyzing a plurality of product lots, each of the product lots having a lot number, the product lots fabricated by way of a plurality of equipment. Each wafer in each product lot is tested according to a plurality of final test items to generate a plurality of final test parameters. The final test items, the final test parameters, and a packaging process step correlated to the final test items are stored in a database. The claimed invention method comprises the following steps. The final test parameters for each lot of products are

retrieved by searching the database. The final test parameters are compared to select a representative final test parameter and a corresponding representative final test item. It is then determined if the 5 representative final test item is correlated to the packaging process step. The representative final test parameters of the plurality of product lots are compared with a predefined spec if the representative final test item is correlated to the packaging process step to 10 classify the product lot having the representative final test parameter greater than the predefined spec into a first failed group, and the product lot having the representative final test parameter smaller than the predefined spec into a first qualified group. The 15 equipment through which the product lots in the first qualified group has passed in the packaging process step is searched. The equipment through which the product lots in the first failed group has passed in the packaging process step is also searched. The 20 equipment having a probability of having processed the first failed group being greater than a probability of having processed the first qualified group is then determined.

25 In addition, each wafer in each product lot is tested according to an in-line quality control item and a sample test item correlated to the final test item to generate an in-line quality control parameter and a sample test parameter. The in-line quality control item, the 30 sample test item, the in-line quality control parameter, and the sample test parameter are stored in the database. According to the present invention method for analyzing final test parameters, the control spec of the in-line quality control or the sample test is revised by

statistically analyzing the testing results acquired from the final test and the in-line quality control or the sample test.

5 It is an advantage of the claimed invention to utilize a plurality of superior product lots as a reference group, and utilize statistical analysis means and commonality analysis means to analyze various testing data and equipment data of the inferior product lots.

10 Therefore, a point causing problems to occur is rapidly and correctly determined when the final test data of semiconductor products indicates abnormalities so that the possibly faulty process step is determined correctly. As a result, malfunctioning equipment is

15 identified. In addition, the control spec of the in-line quality control or the sample test is revised according to analysis results. By effectively reducing mistakes due to a lack of personal experience on the part of a process engineer, processing efficiency

20 is improved, costs are decreased, and the overall in-line production status is improved in time to increase yield rates.

4. Detailed Description

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In the following, relevant drawings are referred to illustrate a method for analyzing final test parameters according to a preferred embodiment of the present invention. Identical components are

30 described with the same reference numbers.

Please refer to Fig. 2 showing a flow chart of a method for analyzing final test parameters according to the preferred embodiment of the present invention. The

preferred embodiment is to analyze and identify malfunctioning packaging equipment.

As shown in Fig.2, first, according to the method 5 for analyzing the final test parameters in the preferred embodiment of the present invention, step 201 is executed to search for a plurality of final test parameters from a plurality of product lots. Then step 10 202 is executed to compare the final test parameters to select a representative final test parameter and a corresponding representative final test item. For example, if there are n product lots, all of the product 15 lots are analyzed according to the final test items comprising item A, item B, and item C, and all of the final test parameters are shown in the table as follows:

Lot Number	Item A	Item B	Item C
Lot 1	20%	5%	6%
Lot 2	19%	7%	9%
Lot 3	23%	5%	7%
.	.	.	.
.	.	.	.
.	.	.	.
Lot n	22%	6%	8%
Average	22%	6%	7%

Each of the percentage values shown in the table 20 represents the failure rate of each lot number in each final test item. In this step, item A, which is the final test item having the highest average failure rate, is selected as the representative final test item. In other words, the representative final test item is a 25 killed final test item, which is the final test item

having the highest average failure rate when a plurality of lots of products are tested.

In the preferred embodiment of the present invention,
5 each product lot, comprising twenty-five wafers, has a lot number. Each product lot is fabricated by way of a plurality of equipment for a plurality of process steps, and is tested according to a plurality of final test items to generate a plurality of final test
10 parameters.

Step 203 is thereafter executed to determine if the representative final test item is correlated to a packaging process step. Generally speaking, each of
15 the final test items is correlated to some specific processing equipment. In the preferred embodiment of the present invention, this correlation is stored in a database to avoid determinations based upon personal judgment.

20

If the representative final test item is determined to not correlate with the packaging process step in step 203, the present invention method will execute analysis for other correlating processes, such as an
25 in-line quality control, a sample test, etc. (as shown in Fig. 3). If the representative final test item is determined to correlate with the packaging process step in step 203, step 204 is executed to classify the plurality of product lots into at least a first qualified
30 group and a first failed group according to the representative final test item. For example, the parameter of each product lot in item A (the failure rate) is compared with a predefined spec of item A (for example: 20%) in this step to determine if the parameter

of each product lot in item A is greater than the predefined spec of item A. If it is not, the product lot is classed into group A (the first qualified group), for example, the lot numbers 1, 2, 3, 4, and 5 (as shown 5 in step 205). If it is, the product lot is classed into group B (the first failed group), for example, the lot numbers 6, 7, 8, 9 and 10 (as shown in step 206).

Next, step 207 is executed to calculate the 10 probabilities of the plurality of equipment through which Group B had passed in the packaging process step. Generally speaking, a plurality of equipment is utilized in one packaging process step, such as E1, E2, E3, etc. In addition, step 208 is executed to 15 calculate the probabilities of the plurality of equipment through which Group A had passed in the packaging process step. Finally, Step 209 is executed to determine the equipment that has a probability of having processed group B that is greater than a 20 probability of having processed group A, by utilizing a commonality analysis means. The equipment having a probability of having processed group B that is greater than a probability of having processed group A, as determined in step 209, is the possibly faulty packaging 25 equipment analyzed according to the method for analyzing final test parameters in the preferred embodiment of the present invention.

Please refer to Fig. 3. Step 301 is executed 30 immediately after the representative final test item is determined to not correlate with the packaging process step in step 203. In step 301, the plurality of product lots are classified into at least a second qualified group and a second failed group according

to the representative final test item. In the preferred embodiment of the present invention, the parameter of each product lot in item A (the failure rate) is compared with the predefined spec of item A 5 (for example: 20%) in this step to determine if the parameter of each product lot in item A is greater than the predefined spec of item A. If it is not, the product lot is classed into the second qualified group. If it is, the product lot is classed into the second failed 10 group.

Step 302 is then executed to search the second qualified group and the second failed group within the database for the in-line quality control item or the 15 sample test item correlated to item A (the representative final test item), and the corresponding in-line quality control parameter or the corresponding sample test parameter, respectively. In the preferred embodiment of the present invention, an in-line quality 20 control item correlated to item A is selected in this step (as shown in step 303).

Next, step 304 and step 305 are executed to determine if there is a discrepancy between the search results 25 of the second failed group and the second qualified group by way of a statistical means. According to the preferred embodiment of the present invention, the parameters acquired from the in-line quality control determined in step 303 are first analyzed in step 304 30 to calculate a mean (average) and a variance of the in-line quality control parameters. Step 305 is then executed to determine if there is a discrepancy between the average and the variance of the in-line quality control parameters of the second failed group and the

average and the variance of the in-line quality control parameters of the second qualified group, respectively. If there is no discrepancy according to the results determined in step 305, the overly high failure rate 5 in item A is not caused by the in-line quality control item selected in step 302 (as shown in step 303), and so the analysis is stopped. If there is a discrepancy according to the results determined in step 305, step 10 306 is executed because the overly high failure rate in item A is probably correlated to the in-line quality control item selected in step 302 (as shown in step 303).

In step 306 to step 311, the causes for the 15 problematic in-line quality control item are analyzed so that a method for revising the control spec of the in-line quality control item is provided.

In step 306, the quantities of out of spec portions 20 in the second failed group and the second qualified group are calculated by way of a statistical means according to a predefined spec of the in-line quality control item selected in step 302 (as shown in step 303). At the same time, a ratio of a number of product 25 lots in the out of spec portion in the second failed group to a total number of product lots in the second failed group, and a ratio of a number of product lots in the out of spec portion in the second qualified group to a total number of product lots in the second qualified 30 group are also calculated. In the preferred embodiment of the present invention, the predefined spec of the in-line quality control item, comprising a predefined up spec limit and a predefined low spec limit, provides a specific range. Therefore, a ratio of a number of

product lots in the second failed group exceeding the predefined up spec limit to a total number of product lots in the second failed group (PaL), and a ratio of a number of product lots in the second qualified group 5 exceeding the predefined up spec limit to a total number of product lots in the second qualified group (PaH) are calculated in this step. In addition, a ratio of a number of product lots in the second failed group being lower than the predefined low spec limit to a 10 total number of product lots in the second failed group (PbL), and a ratio of a number of product lots in the second qualified group being lower than the predefined low spec limit to a total number of product lots in the second qualified group (PbH) are also calculated.

15

Step 307 is thereafter executed to determine if there is a discrepancy between portions in the second failed group exceeding the predefined up spec limit and lower than the predefined low spec limit and portions in the 20 second qualified group exceeding the predefined up spec limit and lower than the predefined low spec limit, by comparing PaL with PaH, and PbL with PbH respectively. If results determined in step 307 indicate that there is a discrepancy, step 308 is executed to determine 25 if the overly high parameters acquired from the representative final test (the parameters acquired from the killed final test item) are caused by deviation of testing results acquired from the in-line quality control item searched in step 302 (as shown in step 303). According to the preferred embodiment of the 30 present invention, a CDF plot may be utilized to output the testing results acquired from the in-line quality control item searched in step 302 (as shown in step 303) in step 308. Engineers are thus allowed to

calibrate and revise the spec data of the in-line quality control according to the CDF plot.

If results determined in step 307 indicate that there
5 is no discrepancy, step 309 is executed to analyze the quantities of out-of-narrowed spec portions in the second failed group and the second qualified group by a statistical means according to a narrowed spec. At the same time, a ratio of a number of product lots in
10 the out-of-narrowed spec portion in the second failed group to a total number of product lots in the second failed group and a ratio of a number of product lots in the out-of-narrowed spec portion in the second qualified group to a total number of product lots in
15 the second qualified group are also calculated. In the preferred embodiment of the present invention, the narrowed spec of the in-line quality control item, comprising an up narrowed spec limit and a low narrowed spec limit, provides a specific range. It is worth
20 noting that the range of the predefined spec is usually six standard deviations for the in-line quality control process, the up narrowed spec limit is one standard deviation smaller than the predefined up spec limit, and the low narrowed spec limit is one standard deviation
25 greater than the predefined low spec limit. As a result, the range of the narrowed spec is usually four standard deviations wide.

A ratio of a number of product lots in the second failed group exceeding the up narrowed spec limit to
30 a total number of product lots in the second failed group (PaL'), and a ratio of a number of product lots in the second qualified group exceeding the up narrowed spec limit to a total number of lots of products in

the second qualified group (PaH') are therefore calculated in step 309. In addition, a ratio of a number of product lots in the second failed group being less than the low narrowed spec limit to a total number of 5 product lots in the second failed group (PbL'), and a ratio of a number of product lots in the second qualified group being lower than the low narrowed spec limit to a total number of product lots in the second qualified group (PbH') are also calculated.

10

Step 310 is then executed to determine if there is a discrepancy between portions in the second failed group exceeding the up narrowed spec limit and being lower than the low narrowed spec limit and portions 15 in the second qualified group exceeding the up narrowed spec limit and being lower than the low narrowed spec limit, by comparing PaL' with PaH', and PbL' with PbH' respectively. If the results determined in step 307 (As the interpreter notes, 307 should be a typographical 20 error of 310.) indicate that there is no discrepancy, the analysis is stopped because the overly high failure rate in item A is not caused by the in-line quality control item selected in step 302 (as shown in step 303). If the results determined in step 310 indicate 25 that there is a discrepancy, step 411 is executed to determine if the overly high parameters acquired from the representative final test (the parameters acquired from the killed final test item) are caused by deviation of testing results acquired from the in-line quality 30 control item searched in step 302 (as shown in step 303). According to the preferred embodiment of the present invention, a CDF plot may be utilized to output the testing results acquired from the in-line quality control item searched in step 302 (as shown in step

303) in step 311. Engineers are thus allowed to calibrate and revise the spec data of the in-line quality control according to the CDF plot.

5 Furthermore, the test item searched in step 302 may be a sample test item according to another preferred embodiment of the present invention. Under the circumstances, the sample test item instead of in-line quality control item is analyzed and results of the 10 sample test are compared (not shown) in steps 303 to 311. As a result, engineers are able to calibrate and revise the spec data of the sample test according to analysis results.

15 In summary, the present invention method for analyzing final test parameters utilizes a plurality of superior product lots as a reference group, and utilizes commonality analysis means to determine the possibly faulty packaging equipment by comparing data, 20 or utilizes statistical analysis means to analyze the in-line quality control data or the sample test data of the inferior product lots. Therefore, the point causing the problem to occur is rapidly and correctly determined when the final test data of semiconductor 25 products indicates abnormalities so that the possibly faulty process step is determined correctly. As a result, malfunctioning equipment is identified. In addition, the control spec of the in-line quality control or the sample test is revised according to 30 analysis results. By effectively reducing error due to a lack of professional experience, processing efficiency is improved, costs are decreased, and the in-line production status is improved in time to increase yield rates.

The above description is exemplificative, but not limitative. The equivalent modifications or variations from the present invention not departing 5 from the spirit and the scope of the present invention should be construed within the scope of the appended claims.

5. Brief Description of Drawings

10

Fig.1 is a flow chart of a prior art method for analyzing final test parameters.

15

Fig.2 is a flow chart of a method for analyzing final test parameters according to a preferred embodiment of the present invention.

Fig.3 is a flow chart continuing the flow in the flow chart as shown in Fig. 3.

Brief Description of Reference Numbers for Components

20

101-104 are steps in the flow of a prior art method for analyzing final test parameters.

25

201-209 are steps in the flow of a method for analyzing final test parameters according to a preferred embodiment of the present invention.

301-311 are steps continuing Step 203.

CLAIMS

What is claimed is:

5 1. A method for analyzing final test parameters, the method being utilized for analyzing a plurality of product lots, each of the plurality product lots having a lot number, the plurality of product lots being fabricated through a plurality of equipment, each wafer
10 in each product lot being tested according to a plurality of final test items to generate a plurality of final test parameters, the final test items, the final test parameters, and a packaging process step correlated to the final test items being stored in a database,
15 the method comprising:

retrieving the final test parameters of the plurality of product lots by searching the database;
comparing the final test parameters to select a representative final test parameter and a corresponding
20 representative final test item;

determining if the representative final test item is correlated to the packaging process step;
classifying the plurality of product lots into at least two first groups according to the representative
25 final test item if the representative final test item is correlated to the packaging process step, the first product groups comprising a first qualified group and a first failed group;

searching for the equipment through which the first
30 qualified group had passed in the packaging process step;

searching for the equipment through which the first failed group had passed in the packaging process step;
and

determining the equipment having a probability of having processed the first failed group greater than a probability of having processed the first qualified group.

5

2. The method of claim 1, wherein the representative final test item is a killed final test item.

10 3. The method of claim 2, wherein the killed final test item is the final test item having the highest failure rate.

15 4. The method of claim 2, wherein the killed final test item is the final test item in which the average of the failure rate of the plurality of lots of wafers is the highest one.

20 5. The method of claim 1, wherein a commonality analysis means is utilized to determine the equipment having a probability of having processed the first failed group greater than a probability of having processed the first qualified group.

25 6. The method of claim 1, wherein each wafer in each product lot is tested according to an in-line quality control (in-line QC) item and a sample test item correlated to the final test item to generate an in-line quality control parameter and a sample test parameter, the in-line quality control item, the sample test item, 30 the in-line quality control parameter, and the sample test parameter are stored in the database, the method further comprises:

classifying the plurality of product lots into at least two second groups according to the

representative final test item if the representative final test item is determined as not correlating to the packaging process step, the second product groups comprising a second qualified group and a second failed group;

5 searching for at least one in-line quality control item or sample test item correlated to the representative final test item, and at least one corresponding in-line quality control parameter and sample test parameter of the second qualified group and the second failed group from the database;

10 statistically analyzing if there is a discrepancy between the searching results of the second failed group and the second qualified group;

15 stopping analyzing if there is not a discrepancy between the searching results;

20 statistically analyzing if there is an obvious discrepancy between an out of spec portion in the second failed group and that in the second qualified group according to a predefined spec if there is discrepancy between the searching results;

25 judging that it is deviation of testing results of the in-line quality control item or the sample test item correlated to the representative final test item causing the over high representative final test parameter if there is an obvious discrepancy according to the predefined spec;

30 statistically analyzing if there is an obvious discrepancy between an out-of-narrowed spec portion in the second failed group and that in the second qualified group according to a narrowed spec if there is not an obvious discrepancy according to the predefined spec;

stopping analyzing if there is not an obvious

discrepancy according to the narrowed spec; and
judging that it is the in-line quality control
item or the sample test item correlated to the
representative final test item causing the over high
5 representative final test parameter if there is an
obvious discrepancy according to the narrowed spec.

7. The method of claim 6, wherein a discrepancy between
the searching results of the second failed group and
10 that of the second qualified group is determined by
determining if there is a discrepancy between a mean
of the searching results of the second failed group
and that of the second qualified group and if there
is a discrepancy between a variance of the searching
15 results of the second failed group and that of the second
qualified group.

8. The method of claim 6, wherein the predefined spec
comprises a predefined up spec limit (USL) and a
20 predefined low spec limit (LSL).

9. The method of claim 8 further comprising determining
if there is a discrepancy between a ratio of a number
of product lots in the second failed group exceeding
25 the predefined up spec limit to a total number of product
lots in the second failed group, and a ratio of a number
of product lots in the second qualified group exceeding
the predefined up spec limit to a total number of
product lots in the second qualified group.

30 10. The method of claim 8 further comprising determining
if there is a discrepancy between a ratio of a number
of product lots in the second failed group lower than
the predefined low spec limit to a total number of

product lots in the second failed group, and a ratio of a number of product lots in the second qualified group lower than the predefined low spec limit to a total number of product lots in the second qualified group.

11. The method of claim 8, wherein the narrowed spec comprises an up narrowed spec limit and a low narrowed spec limit; the up narrowed spec limit is smaller than the predefined up spec limit, and the low narrowed spec limit is greater than the predefined low spec limit.

12. The method of claim 11, wherein a range of the predefined spec is six times a standard deviation, the up narrowed spec limit is one standard deviation smaller than the predefined up spec limit, and the low narrowed spec limit is one standard deviation greater than the predefined low spec limit.

13. The method of claim 10 (As the interpreter notes, 10 should be a typographical error of 11.) further comprising determining if there is a discrepancy between a ratio of a number of product lots in the second failed group exceeding the up narrowed spec limit to a total number of product lots in the second failed group, and a ratio of a number of product lots in the second qualified group exceeding the up narrowed spec limit to a total number of product lots in the second qualified group.

14. The method of claim 10 (As the interpreter notes, 10 should be a typographical error of 11.) further comprising determining if there is a discrepancy

between a ratio of a number of product lots in the second failed group lower than the low narrowed spec limit to a total number of product lots in the second failed group, and a ratio of a number of product lots in the 5 second qualified group lower than the low narrowed spec limit to a total number of product lots in the second qualified group.

15. The method of claim 6, wherein a CDF plot is utilized 10 to output the testing results of the in-line quality control item or the sample test item correlated to the representative final test item if there is an obvious discrepancy according to the predefined spec.
15. 16. The method of claim 6, wherein a CDF plot is utilized to output the testing results of the in-line quality control item or the sample test item correlated to the representative final test item if there is an obvious discrepancy according to the narrowed spec.

20

ABSTRACT

A method for analyzing final test parameters. The method is utilized for analyzing a plurality of product lots. Each of the plurality product lots has a lot number. Each product lot is fabricated through a plurality of equipment, and each wafer in each product lot being tested according to a plurality of final test items to generate a plurality of final test parameters. The final test items, the final test parameters, and a packaging process step correlated to the final test items are stored in a database. The method includes the following steps: To retrieve the final test parameters of each product lot by searching a database. To compare the final test parameters to select a representative final test parameter and a representative final test item. To determine if the representative final test item is correlated to a packaging process step. To classify the plurality of product lots into at least a first qualified group and a first failed group according to the representative final test item if there is correlation. To search for the equipment through which the first qualified group had passed in the packaging process step. To search for the equipment through which the first failed group had passed in the packaging process step. To determine the equipment having a probability of having processed the first failed group being greater than a probability of having processed the first qualified group.

30

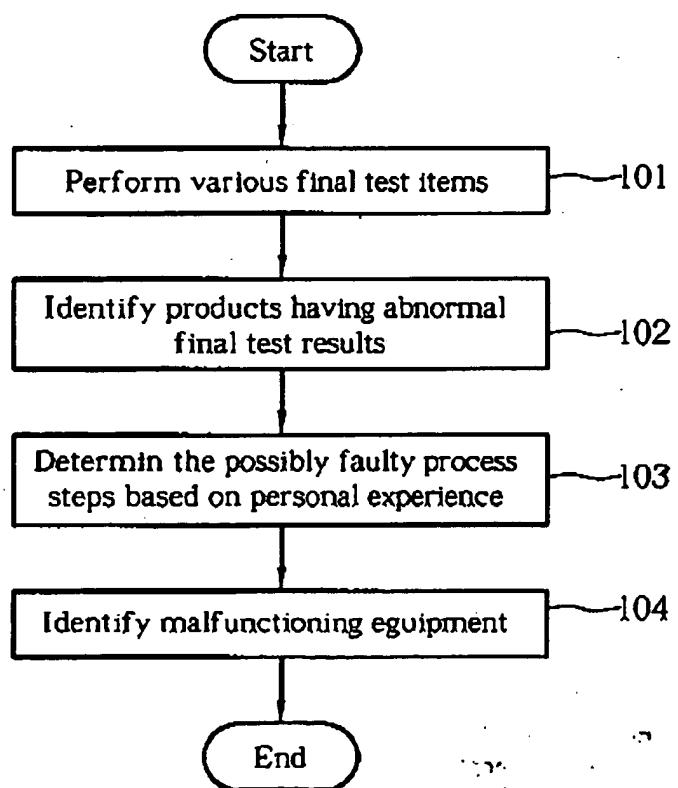


Fig. 1

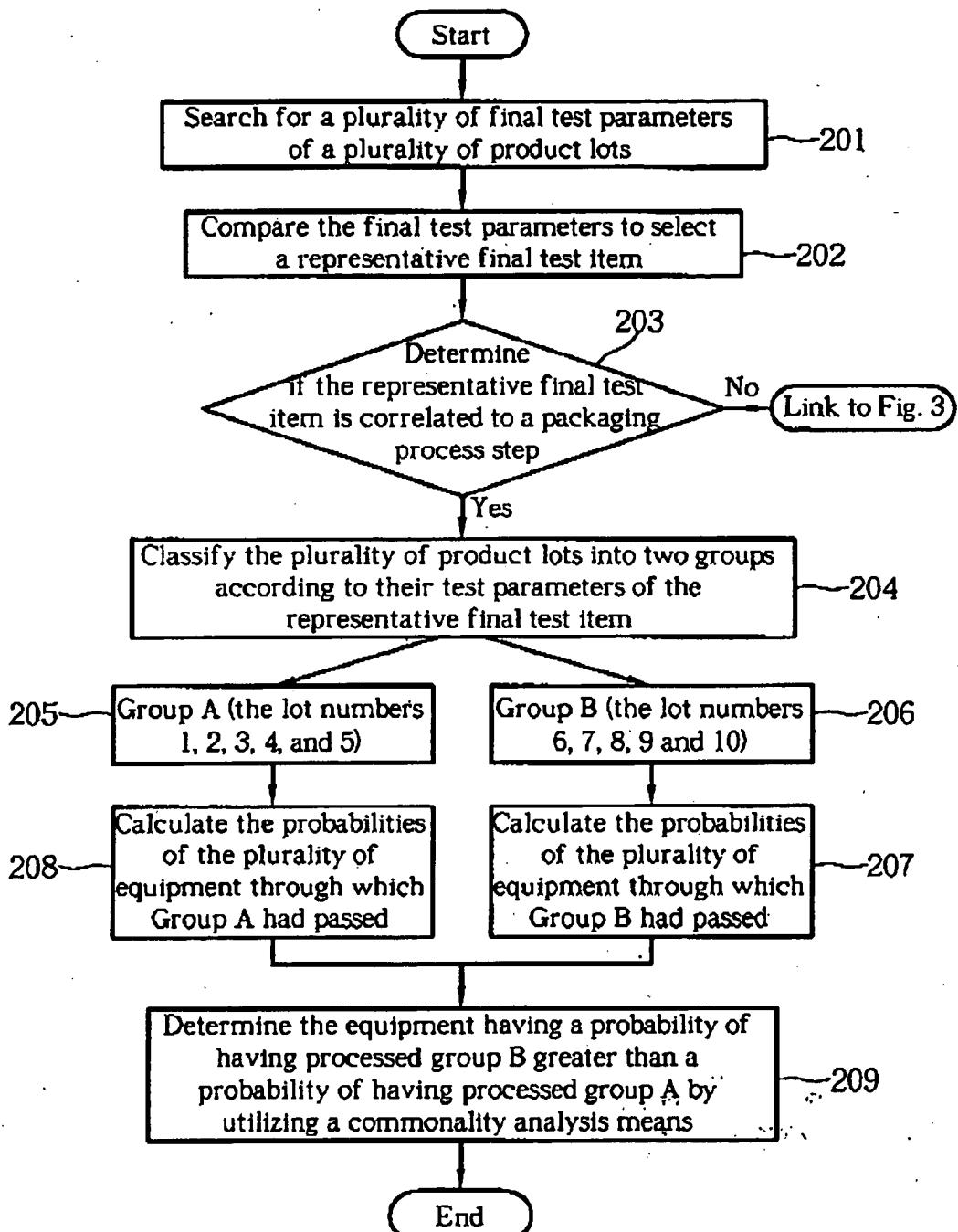


Fig. 2

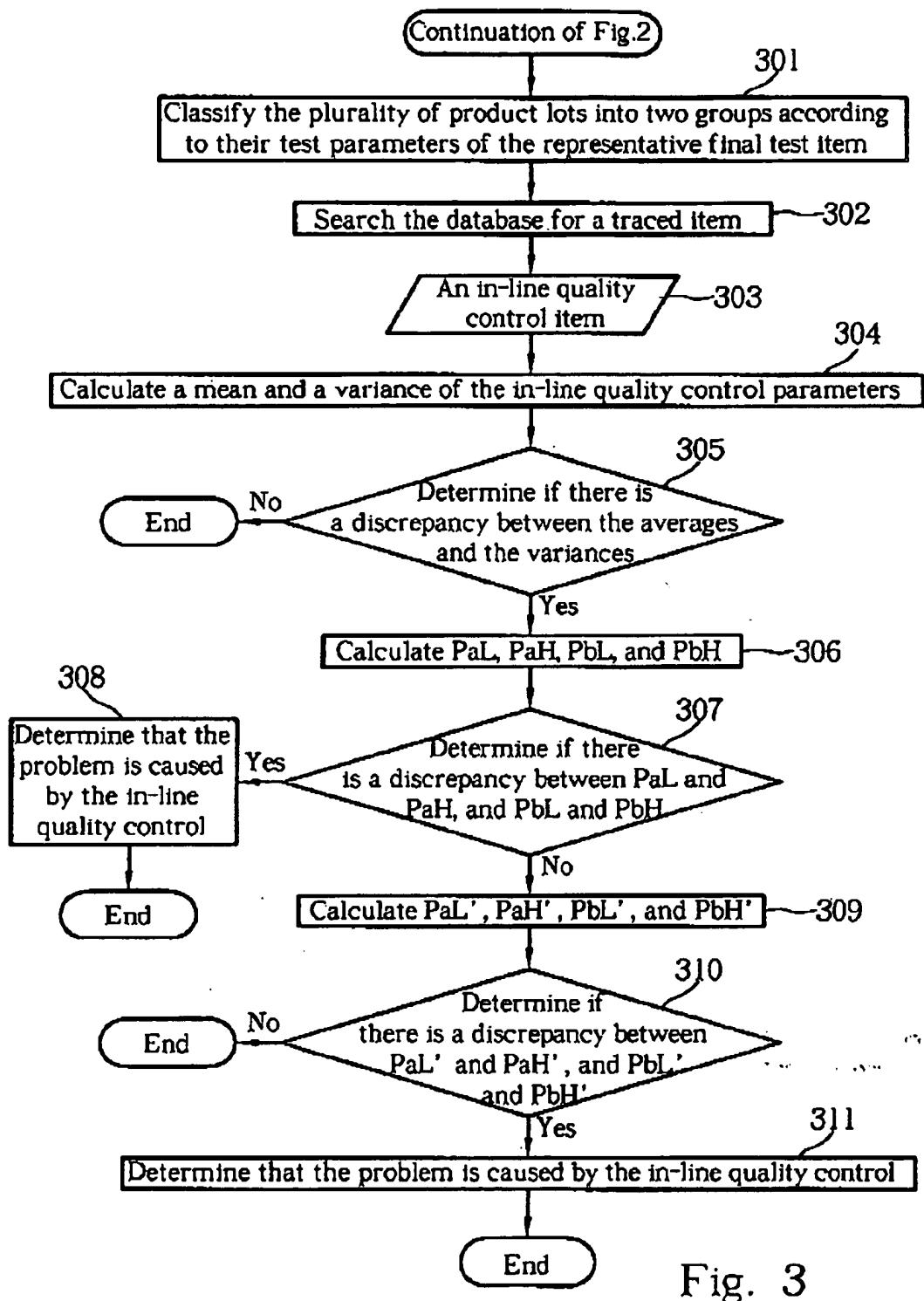


Fig. 3